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# Threats Associated with Non-infectious Diseases in Modified Extensive Shrimp Farming Systems of West Bengal, India

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## Abstract

The influence of farm establishment and management practices adopted in modified extensive shrimp farms of West Bengal, India on the non-infectious diseases was studied. A total of 60 shrimp farms culturing *Penaeus monodon* were randomly taken for the study. Information was collected through a structured questionnaire by interviewing the farmers, taking into account all their management practices such as farm establishment, pre-stocking management, stocking management and post-stocking management and particulars regarding disease occurrence during 2001 and 2002 covering two crops. The data generated were evaluated for their association with disease outbreak. Three major non-infectious diseases viz., epicommensal fouling, soft-shelling and gill choking were noticed during the study. Among the variables studied, provision for inlet/outlet, pond ploughing, pond desilting, duration of pond preparation, source of seeds, acclimatization, stocking density, mean water exchange per day, type of aeration and number of crops taken in a year were found to be significantly associated with the incidence of non-infectious diseases.

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## Introduction

Rapid development of the shrimp culture has been accompanied by the occurrence of diseases induced by both natural and man-made environmental changes. Epizootics of varied etiology are being increasingly recognized and have continuously beleaguered the various sectors of the shrimp culture industry. Besides dreaded infectious diseases, the diseases of non-infectious etiology have also been causing considerable damage to the shrimp industry globally (Lightner 1993a). Sindermann (1990) categorised non-infectious diseases and abnormalities of shellfishes as diseases caused by contaminant stress, stress provoked latent infection, environmentally induced abnormalities and nutritional deficiency. The important non-infectious diseases which may pose serious problems in shrimp are epicommensal infestation, cramped muscle, chronic soft-shell syndrome, gas bubble disease, muscle necrosis, toxic algal diseases, black-gill disease and parasitic protozoa (Limsuwan 1993; Joshua et al. 1994; Alavandi et al. 1995). Some of these diseases have simple, straightforward etiologies, while others have complex etiologies in which affected animals succumb to infections by opportunistic pathogens after an initial insult by other predisposing factors (Sindermann 1990). Hence, a basic understanding of the etiology of the disease condition is highly essential to maintain a healthy shrimp population in a culture system.

West Bengal commands rich resources for aquaculture in India. It has immense potential for commercial farming of shrimp. Currently, around 49,925 ha (2003-2004) are under shrimp culture in West Bengal. The production of shrimp through aquaculture in this State increased from 12,500 t during the year 1990-1991 to 29,714 t in 2003-2004 contributing nearly 23% of total shrimp production of the country (Dehadrai 2006). The dominant species under culture are *Penaeus monodon* followed by *Fenneropenaeus indicus* and *Metapenaeus* spp. Excluding the traditional shrimp culture, majority of the shrimp farmers in this State follow modified extensive farming. The major constraint in shrimp culture is the problem associated with disease management. The present study was, therefore, taken up to study the influence of farm establishment and management practices adopted in modified extensive farms on the non-infectious diseases.

# Materials and Methods

## *Description of study area*

The Midnapore (East) district, West Bengal, India has a good potential for shrimp farming. It is estimated that more than 3,000 ha of the area has been under shrimp farming. Majority of the farmers in the district follow a modified extensive type of shrimp culture, whereas, other types of shrimp farming are sporadic. Hence, modified extensive farms were selected for the detailed survey to record and evaluate various management aspects with disease outbreak. The epidemiological survey areas included in the Contai Zone (21°48'N-87°45'E) were Rasulpur and Petuaghat which receive water from Rasulpur river, and Auria and Korpura which draw water from the Rasulpur canal.

## *Method of data collection*

A total of 60 shrimp farms culturing *P. monodon* were randomly taken for the study. Information was collected through a structured questionnaire by interviewing the farmers. Questionnaire was prepared by taking into account all the management practices such as farm establishment, pre-stocking management, stocking management and post-stocking management like pond preparation, stocking, feeding and water quality management, harvest and particulars regarding disease occurrence during 2001 and 2002 covering two crops. The structured questionnaire was pre-tested by conducting a pilot survey wherein errors and omission were rectified. The final survey was conducted by using the pre-tested questionnaire in the selected farms. The data were collected by interviewing the shrimp farmers/farm technicians personally in their farms. The possible major factors influencing disease occurrence were selected from the available literature and the data generated were evaluated for their association with disease outbreak. A list of 21 variables with their description, on which data collected and evaluated for their association with non-infectious diseases, is presented in table 1. The disease outbreak in the farms was confirmed based on clinical signs, microscopic observations and histopathology as described in Baticados et al. (1986), Bell and Lightner (1988) and Lightner (1993a; 1993b).

## *Statistical analysis*

Chi-square ($\chi 2$) test was carried out to know the association/independence of variables (farm design, establishment and manage

Table 1. List of variables selected for evaluating their association with non-infectious diseases

| Name of the variable | Variable description |
|---|---|
| Farm Establishment Details: | |
| 1. Size of the farm | Size of the farm was recorded based on the water spread area and grouped into <1ha, 1.0-2.0 ha and 2.1-3.0 ha. |
| 2. Number of ponds in the farm | Number of ponds varied between 1 and 6. |
| 3. Activity nearby shrimp farm | The nearby activities included agriculture, shrimp farming and/or both. |
| 4. Age of the farm | Age of the farm was calculated based on the total year of operation and was varied from 1 year to 8 years. |
| 5. Provision for Inlet-outlet | Presence or absence of inlet-outlet was recorded. |
| 6. Source of water | The farms drew water either from Rasulpur river or Rasulpur canal. |
| 7. Reservoir ponds | The farms were categorized into farms with reservoirs and without reservoirs |
| Pre-Stocking Management: | |
| 8. Pond ploughing | Number of ploughing practiced in the farms was categorized as the farms that ploughed once, twice and thrice. |
| 9. Pond desilting | The depth (cm) of pond desilting was grouped into three types namely farms, which did not desilt (0 cm) the ponds, desilted to a depth of 5 cm and 10 cm. |
| 10. Predators | Presence or absence of predators was recorded. |
| 11. Duration of pond preparation | The duration of pond preparation was categorized into four types such as 10-20 days, 21-30 days, 31-40 days and 41-50 days. |
| Stocking and Post-Stocking Management: | |
| 12. Source of seeds | Farms stocked seed procured from hatchery, wild or both. |
| 13. Uniformity in the size of seeds | Uniformity in the size of seeds at the time of stocking was recorded. |
| 14. Acclimatization | Acclimatization procedure adopted was documented. |
| 15. Stocking density | The stocking densities (nos/$m^2$) were categorized into five groups, i.e. 3-6, 7-10, 11-14 and 15-18. |
| 16. Freshness of feed | The farms were categorized into three types, viz., farms that used fresh feed, old feed or both. |
| 17. Feeding frequency | The feeding frequency per day adopted in the farms was grouped into 4, 3 and 2. |
| 18. Mean water exchange per day | The mean water exchange per day adopted in farms was classified into five categories namely nil, need based, 1-5%, 5-10% and >10%. |
| 19. Type of aeration | The type of aeration followed in the farms was categorized into three groups, i.e., nil, manual and pumping. |
| 20. Days of culture (DOC) | The DOC at the time of disease outbreak was documented. |
| 21. Number of crops taken in a year | Number of crops taken in a year was either one or two. |

ment practices) and disease incidence as per Snedecor and Cochran (1968). Further, the extent of association was assessed by calculating Co-efficient of contingency (C) by using the formula

$$C = \sqrt{[\chi 2/\chi 2 + N]}$$

Where, C = Coefficient of contingency, $\chi 2$ = Calculated $\chi 2$ value, and N = Total number of ponds.

## Results and Discussion

The major constraint in shrimp culture is the problem associated with disease management. The maxim *"Prevention is better than cure"* is well applicable here. This can be accomplished by proper management practices based on scientific principles such as thorough pond preparation, water quality management and feed management.

### *Farm establishment*

The farm establishment begins with proper site selection, which plays a major role in shrimp farming. The determination of a site for shrimp farming is made only after a thorough analysis of information on topography, ecosystem, meteorological and socioeconomic conditions in relation to farm design, species compatibility and economic viability. Among the farm establishment characteristics, provision for inlet / outlet was found to be significantly ($p<0.05$) associated with the incidence of diseases.

### *Provision for inlet and outlet*

The incidence of diseases ranged from 50% of the farms which had separate inlet and outlet to 80% of the farms where there was no provision for inlet/outlet (Table 2). Separate inlet and outlet gates facilitate effective water exchange, pond preparation and harvesting. The farms, which had no provision for inlet/outlet might have encountered problems with pond preparation and water exchange and hence, the higher disease incidence. Leung et al. (2000) recorded lower disease incidence in the farms, which had separate inlet and outlet. Contrary to this, Baticados et al. (1986) could not find any association of inlet/outlet with soft-shelling in *P. monodon.*

### *Pre-stocking management*

Pre-stocking management includes pond bottom condition and preparation, predator eradication, fertilization and phytoplankton bloom control. These steps have great significance and often decide the stocking and post-stocking management practices to be adopted. Inadequate pond preparation is one of the most critical problems of the shrimp growers. It was observed that pond ploughing, pond desilting and duration of pond preparation were found to be significantly ($p<0.05$) associated with the incidence of diseases.

Table 2. Relationship between the farm establishment variables and disease outbreak

| Variable | Description | % of farms (N=60) | % of farms affected by non-infectious diseases (n=42) | Chi square | Coefficient of contingency (C) |
|---|---|---|---|---|---|
| Size of the farm (ha) | < 1 | 46.67 | 60.71 | 2.2052 | - |
| | 1.0 – 2.0 | 40.00 | 79.16 | | |
| | 2.1 – 3.0 | 13.33 | 75.00 | | |
| Number of ponds per farm | 1 – 2 | 53.3 | 59.37 | 3.7202 | - |
| | 3 – 4 | 30.0 | 83.33 | | |
| | 5 – 6 | 16.67 | 80.00 | | |
| Activity nearby farm | Agriculture | 46.67 | 71.43 | 1.1940 | - |
| | Shrimp farming | 30.00 | 61.11 | | |
| | Both | 23.33 | 78.57 | | |
| Age of the farm (years) | 8 | 5.0 | 66.66 | 2.3396 | - |
| | 7 | 10.0 | 83.33 | | |
| | 6 | 11.7 | 71.42 | | |
| | 5 | 15.0 | 77.77 | | |
| | 4 | 10.0 | 83.33 | | |
| | 3 | 11.7 | 57.14 | | |
| | 2 | 15.0 | 66.66 | | |
| | 1 | 21.7 | 61.54 | | |
| Provision for inlet / outlet | None | 25.00 | 80.00 | 6.6883* | 0.3167 |
| | Single | 55.00 | 72.72 | | |
| | Separate | 20.00 | 50.00 | | |
| Source of water | Rasulpur river | 41.67 | 60.00 | 1.3061 | - |
| | Rasulpur Canal | 58.33 | 77.14 | | |
| Provision for reservoir | Yes | 16.67 | 70.00 | 0.1428 | - |
| | No | 83.33 | 70.00 | | |

* Significant difference ($p<0.05$)

## *Pond ploughing*

In the present survey it was observed that disease incidence was higher in the ponds that did not plough and stocked more than 10 post larvae·$m^{-2}$. The disease incidence abated with the increase in number of ploughs and was significantly associated (Table 3; $\chi 2$ = 5.9939; $p<0.05$). The results also corroborate Sukumar's study (1998) who recorded a reduction in disease incidence from 100 to 50% when pond ploughing increased from once to four times. Ploughing facilitates exposure of hidden layers of sediment to the sun and eliminates toxic gases such as ammonia, hydrogen sulphide and methane (Kongkeo 1995). By this process, the organic waste will be oxidized. Ploughing also reportedly diminishes soil iron content in culture ponds with acid-sulphate soils (Cook et al. 1984). Ploughing on wet soil is particularly recommended for ponds if the planned stocking density is between 6 and 10 post larvae·m$^{-2}$ and when the sludge cannot be removed properly by manual or mechanical methods (MPEDA/NACA 2003).

Table 3. Relationship between the pre stocking variables and disease outbreak

| Variable | Description | % of farms (N=60) | % of farms affected by non-infectious diseases (n=42) | Chi square | Coefficient of contingency (C) |
|---|---|---|---|---|---|
| Number of ploughs | 1 | 50.00 | 83.33 | 5.9939* | 0.3014 |
| | 2 | 35.00 | 61.90 | | |
| | 3 | 15.00 | 44.44 | | |
| Desilting depth (cm) | 0 | 35.00 | 80.95 | 7.1202* | 0.3257 |
| | 5 | 50.00 | 73.33 | | |
| | 10 | 15.00 | 33.33 | | |
| Predators | Present | 46.67 | 71.42 | 0.0038 | - |
| | Absent | 53.33 | 68.75 | | |
| Duration of pond preparation (Days) | 10 – 20 | 23.33 | 85.71 | 6.1033* | 0.3038 |
| | 21 – 30 | 38.33 | 73.91 | | |
| | 31 – 40 | 21.67 | 69.23 | | |
| | 41 – 50 | 16.67 | 40.00 | | |

* Significant difference ($p<0.05$)

## *Pond desilting*

Pond desilting is necessary to remove the fouled layer of pond bottom. Sedimentation occurs as a result of heavy organic inputs (feed, fertilizers, plankton) and suspended materials introduced through water exchange or surface run-off during rainy season. Akiyama (1992) recommended a desilting depth of 10-20 cm depending on the pond bottom condition. Desilting is essential in farms where stocking densities are more than 6 post larvae·m$^{-2}$ and in those which had experienced diseases during previous crop. If the sludge is removed properly the management of the pond becomes easier during high pH periods (MPEDA/NACA 2003). There existed a significant association between the pond desilting and disease occurrence ($p<0.05$; C=0.3257). The disease occurrence was increased with the reduction in the depth of desilting (Table 3). The accumulation of unconsumed feeds, shrimp excreta and decayed matter from the pond biota could favour the proliferation of pathogens in those ponds, which was not desilted, or desilted to lesser depths. The observations of the present study are in accordance with Kongkeo (1995). Contrary to this, Leung et al. (2000) found no significant association between desilting and disease occurrence. They stated that silt removal either exposes disease-producing sediments, or perhaps newly exposed sediments somehow stress shrimp, thus, leading to disease problems.

### *Duration of pond preparation*

Being a critical step in shrimp farming, pond preparation has to be carried out with paramount care. In the present study area the farmers took 10-50 days to prepare their ponds. The duration of pond preparation was found to be significantly associated with the outbreak of diseases ($p<0.05$; C=0.3038). Higher disease incidence (62%) was recorded in farms which took less than 30 days of pond preparation, while it reduced to 40% in farms that took about 41-50 days of preparation period (Table 3). Drying the pond bottom facilitates exposing the surface sediments, oxidizing reduced compounds, decomposition and mineralization of organic matter, disinfection of pond bottom and elimination of undesirable algal mats. A pond preparation period of 15-45 days (Akiyama 1992; Boyd 1995) and facilitation of solar oxidation by allowing the pond bottom to dry and crack to a depth of 2-5 cm (Villalon 1991) was suggested. Kongkeo (1995) attributed thorough pond preparation to successful shrimp farming in Thailand and suggested a minimum period of 30 days for the preparation of ponds. This perhaps provides an explanation for the higher disease incidence in the farms that took less than 30 days for pond preparation. Leung et al. (2000) observed that extensive farms were less prone to diseases when pond soils were thoroughly dried between crops. It, however, had no effect on disease in semi-intensive and intensive ponds.

### *Stocking and post-stocking management*

Stocking management involves selection of good quality post-larvae, proper acclimatization, optimum stocking density, feed management and water quality management. It was observed that source of seeds, acclimatization, stocking density, mean water exchange per day, type of aeration and number of crops taken in a year were found to be significantly ($p<0.05$) associated with disease occurrence (Table 4).

Table 4. Relationship between the stocking and post stocking variables and disease outbreak. * Significant difference ($p<0.05$)

| Variable | Description | % of farms (N=60) | % of farms affected by non-infectious diseases (n=42) | Chi-square | Coefficient of contingency (C) |
|---|---|---|---|---|---|
| Source of seeds | Hatchery | 56.7 | 76.5 | 5.3200* | 0.2854 |
| | Feral | 15.0 | 44.4 | | |
| | Hatchery and feral | 28.3 | 70.6 | | |
| Uniformity in size of seeds | Yes | 70.0 | 66.7 | 0.3061 | - |
| | No | 30.0 | 77.8 | | |
| Acclimatization | Yes | 33.3 | 45.0 | 7.2321* | 0.3279 |
| | No | 66.7 | 82.5 | | |
| Stocking density (no.$m^{-2}$) | 3 – 6 | 6.7 | 25.0 | 9.5900* | 0.3712 |
| | 7 – 10 | 23.3 | 64.3 | | |
| | 11 – 14 | 46.7 | 71.4 | | |
| | 15 - 18 | 23.3 | 85.7 | | |
| Freshness of feed | Fresh | 46.7 | 57.1 | 4.3300 | - |
| | Fresh and Old | 40.0 | 79.2 | | |
| | Old | 13.3 | 87.5 | | |
| Feeding frequency (per day) | 4 | 50.0 | 66.7 | 0.0088 | - |
| | 3 | 38.3 | 69.6 | | |
| | 2 | 11.7 | 71.4 | | |
| Mean water exchange per day | Nil | 21.7 | 100.0 | 8.7697* | 0.3571 |
| | Need based | 38.3 | 78.2 | | |
| | 1 – 5 % | 16.7 | 60.0 | | |
| | 5 – 10 % | 15.0 | 55.5 | | |
| | > 10% | 8.3 | 20.0 | | |
| Type of aeration | Nil | 26.7 | 87.5 | 6.2857* | 0.3079 |
| | Manual | 31.7 | 73.7 | | |
| | Pumping | 45.0 | 51.8 | | |
| Days of culture (DOC) | 0 – 25 | 16.7 | 71.4 | 2.7750 | - |
| | 26 – 50 | 47.6 | 55.0 | | |
| | 51 – 75 | 21.4 | 33.3 | | |
| | 76 – 100 | 9.5 | 25.0 | | |
| | > 100 | 4.7 | 00.0 | | |
| Number of crops taken in a year | 1 | 35.0 | 42.8 | 9.433* | 0.3685 |
| | 2 | 65.0 | 84.6 | | |

### *Source of seed*

The farmers in the study area used seeds from hatchery and feral collections or both. The seeds were brought mainly from the hatcheries of Andhra Pradesh, India, as they were less costly and they could be obtained on loan/credit basis. None of the farms reported polymerase chain reaction (PCR) screening of seeds for white spot syndrome virus (WSSV) before obtaining from the hatchery. A significant association was noticed between the source of seeds and disease incidence ($p<0.05$; C=0.2853). The extent of association was, however, low (C=0.2853). Higher disease incidence (76%) was noticed in the farms which stocked hatchery seeds (Table 4). Contrast to this, Corsin et al. (2001; 2003) could not notice any significant association between either source or activity of seeds and WSSV disease in *P. monodon*. They related it to the variety of suppliers and treatments leading to a lack of statistical power. The observed low incidence of disease in the farms that stocked only feral seeds might be due to their hardy nature of wild seeds, which tolerate fluctuations in environmental factors better than the hatchery produced seeds.

### *Acclimatization*

Acclimatization is an important step before releasing the seeds into the ponds. It helps the shrimp to adjust to new environment. Without acclimation shrimp larvae will die and the actual stocking density would be less than expected (Akiyama 1993). This would lead to excess feeding, deterioration of the pond ecosystem and ultimately the shrimp succumb to stress and diseases. A significant association was found in the present study, between acclimatization and disease incidence ($p<0.05$; C=0.3279). The duration of acclimatization, ranged from 30 to 60 min in those farms which followed this practice. The incidence of disease was more (82%) in farms which did not acclimatize the shrimp (Table 4). Kumlu and Jones (1995) recorded 100 and 80% mortality of post-larvae of *F. indicus* when they were transferred from a salinity level of 30 to 5 and 10 ppt, respectively without acclimation. Leung et al. (2000) stated that the longer the duration of acclimatization the lower the occurrence of disease. Corsin et al. (2001), however, could not observe any association between the method of acclimatization and WSBV presence at harvest.

### *Stocking density*

Stocking density plays an important role in deciding the growth and survival of shrimp, and productivity of the pond. Many times management practices have to be devised based on stocking density alone. A significant association between stocking density and disease incidence was observed ($p<0.05$; $C=0.3712$). It was found that the intensity of disease increased with increasing stocking densities, which ranged between 25% in the farms stocked at $3\text{-}6{\cdot}m^{-2}$ and 86% in farms stocked at $15\text{-}18{\cdot}m^{-2}$ (Table 4). As stocking densities increase, culture system is overloaded with nutrients. Active microbial decomposition can cause oxygen depletion and result in a reduced environment leading to abated growth (Ray and Chien 1992) and even causing diseases such as gill rot, external protozoan infestation or nematode parasitism (Liao et al. 1985). Increased prevalence of disease has been associated with increased stocking density (Overstreet 1973; Hanson and Goodwin 1977; Doubrovsky et al. 1988), which is in accordance with the present study. Baticados et al. (1986) recorded increased incidence of soft-shelling with the increase in stocking density from extensive to semi-intensive and intensive culture systems. Contradictory to above findings, Hegde (1997) and Corsin et al. (2001), however, recorded WSSV incidence in the shrimp ponds irrespective of the stocking density.

### *Mean water exchange per day*

As seen in table 4, the mean water exchange per day varied between nil and >10%. There existed a significant association between the mean water exchange per day and disease outbreak ($p<0.05$; $C=0.3571$). The disease incidence was the maximum (100%) in farms which had no water exchange (Table 4). The lack of provision for water exchange could be attributed to inadequate infrastructure facilities, as many of the farms are owned by small-scale shrimp farmers. The water exchange reportedly remove accumulated organic load and toxic metabolites, bring natural food, influence water quality parameters and stimulate moulting in shrimp (Parker and Suttle 1987), thus, influence disease occurrence. However, Kongkeo (1995) is of the opinion that water exchange introduces viruses, other pathogens, excess organic loads, ammonia and other toxic particles released by nearby farms, if proper care is not taken. Absence of water exchange or even inadequate water exchange might have resulted in accumulation of organic load and deterioration of water quality thereby causing stress and disease to shrimp. Baticados et al. (1986) related insufficient or infrequent water exchange to soft-shelling in shrimp. Leung et al. (2000) recorded low disease occurrence with increased water exchange frequency towards the terminus of culture in intensive system, but not in semi-intensive and extensive culture systems.

### *Type of aeration*

Aeration is necessary in culture ponds when organic loading drives the pond ecosystem from autotrophy to heterotrophy (Madernjian 1990). Aeration not only supplements the natural dissolved oxygen but also facilitates the organic load to accumulate at the center which can be removed easily thereof. In the present survey it was noticed that while some farms used pumping as a mean of aeration others have done manually. Some farms did not have any facilities for aeration. The type of aeration was significantly associated with disease incidence ($p<0.05$; C=0.3079). Among the affected farms, 87% did not aerate the ponds (Table 4). In contrast, Leung et al. (2000) noticed increased disease occurrence with aeration in semi-intensive systems, which may be due to the result of disease rather than cause.

### *Number of crops taken in a year*

The incidence of disease was high (85%) in farms which had two crops in a year compared to those which had only one crop (43%). There existed a significant ($p<0.05$; C=0.3685) association between the number of crops taken in a year and incidence of disease (Table 4). The 'crop holiday' or 'down time' (the interval or the duration between two successive crops) to reduce the disease outbreak has been suggested (Villalon 1991; MPEDA 1995). Those farms which took two crops in a year had an interval of 10-15 days. As the interval between crops was less, pond drying and preparation was not proper, which resulted in serious problems in the subsequent crop. However, Marichamy (1995) opined that crop holiday up to 4 months did not prevent disease outbreak. Verghese (1995) is of the view that alternative crops (rotation of crops) would provide ecological purification and, hence, a reduction in the disease incidence.

## Conclusion

The gross and clinical signs observed in the present study were alike for both the years. The most common ones were erratic swimming, surfacing, broken antennae, lethargy, concentrating in pond edges, white spots on the inner side of carapace, empty gut, algal fouling, red discolouration and broken appendages.

Three major non-infectious diseases occurred during the present study, viz., epicommensal fouling, soft-shelling and gill choking (Table 5).

Table 5. Incidence of diseases in shrimp farms

| Disease/Abnormalities | Percentage (n=42) |
|---|---|
| Non-infectious diseases | |
| Epicommensal fouling | 50.00 |
| Soft-shelling | 36.67 |
| Gill choking | 43.33 |
| Un-even growth | 25.00 |
| Algal bloom | 8.33 |
| Loose-shelling | 8.33 |
| Double shelling | 5.00 |
| Yellow discolouration | 3.33 |
| Weedy fauna in ponds | 16.67 |
| Jelly fish | 15.00 |
| Infectious diseases | |
| White spot syndrome viral (WSSV) disease | 30.00 |
| Red discolouration | 33.33 |
| Vibriosis / luminous vibriosis | 31.67 |
| Shell disease | 5.00 |

Three epicommensals, *Zoothamnium, Epistylis* and *Vorticella* were recorded. Among them *Zoothamnium* was the most common and its intensity was high in all the farms. Other abnormalities noticed were uneven growth, weedy fauna in ponds, jellyfish problem, loose shelling, double shelling, and yellow discolouration. However, the intensity of these abnormalities, except uneven growth, was relatively low. The important infectious diseases associated with non-infectious diseases are WSSV disease, red disease and vibriosis.

One of the most interesting features in the sequence of disease outbreak was the occurrence of infectious diseases after an initial exert by non-infectious etiology. High incidence of infectious diseases was noticed in the farms which recorded higher percentage of non-infectious diseases. Thus, it appears that an early assessment and subsequent management of non-infectious diseases would prevent the shrimp from succumbing to the infectious diseases and, thereby, help avoiding further losses.

Many of these findings may be relevant only in this region and may differ over time. Therefore, the findings should be generalized with great heed. The possible risk factors identified here will have to be tested in intervention studies in order to evolve effective health management strategies. The findings would help refine future farm surveys and, thereby, provide even greater insights into the causes of shrimp diseases as well as draw attention of farmers to evolve suitable management practices as suggested.

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